Paper

Technical and Regulatory Issues of Emergency Call Handling

Wojciech Michalski

Abstract—The paper presents selected technical and regulatory aspects of emergency call handling in communication between citizens and authorities in case of distress. Among the most important technical aspects of emergency call handling are recognition and treatment of emergency call by originating network, routing of such call to the appropriate public safety answering point (PSAP), delivering call-related information to the PSAP as well as architecture and organization of PSAPs. From the legal point of view, of importance are the obligations for the Member States and stakeholders involved in the E112 project included in the EU directives, actions of European Commission related to providing access to the location information as well as obligations concerning emergency call handling included in Polish national law.

Keywords—calling line identity, emergency call, location information, public safety answering point.

1. Introduction

Every year in the European Union several millions of citizens dial an emergency number to access emergency services. It is observed that due to rising penetration of mobile telephony, the share of emergency calls originating from mobile networks grows continuously. Unfortunately, many mobile callers in an emergency situation are not able to indicate their location today.

Such situation makes the work of emergency services extremely difficult since their efficiency, and in particular their response time, depend on knowledge of the caller's location.

Taking into account that an emergency can be anything, from every day incidents like traffic accidents or assault, to major incidents like aeroplane crashes or forest fires, to major disasters such as earthquakes or large-scale terrorist attacks, the emergency communications (EMTEL) elaborated on a broad spectrum of issues related to use of telecommunication services in emergency situations, addressing European Telecommunications Standard Institute (ETSI) members and all stakeholders involved in E112 project.

Currently, ETSI works on defining the user requirements for the four main areas of emergency communications. One of them is emergency call handling – communication from citizens to authorities/organizations. The second comprises public safety communications between authorities/organizations. The next one regards warning systems – communication from authorities/organizations to citizens. The last one concerns the communications amongst citizens during emergencies.

The article presents technical problems of emergency call handling and regulatory issues related to introduction of E112 in public networks in accordance with current telecommunication standards as well as European Union and Polish regulations.

2. Definitions

Emergency call is the call originating from a user to an emergency control centre (ECC), where ECC means the facilities used by emergency response organizations like police, fire brigade and emergency medical services to handle emergency calls.

Emergency call is forwarded to the emergency control centre by public safety answering point (PSAP). The PSAP is treated as physical location where emergency calls are received under the responsibility of a public authority.

Emergency calls are handled under E112 (enhanced 112) defined as emergency communications service using the single European emergency call number 112, which is enhanced with location information of the calling user.

3. Speech Quality and Priority of Emergency Calls

Emergency calls should have priority over all other calls and the priority should be ensured across public networks.

In the fixed network priority should be given from the network access point (associated with the emergency call originated from this point) to the network termination point or PSAP to which appropriate emergency control centre is connected.

In the mobile network priority should be given from the mobile switching centre (MSC), including the air interface, to the network termination point or public safety answering point to which an appropriate emergency control centre is connected.

If the network is not operating under abnormal conditions as a result of a disaster, the speech quality of emergency calls should not be worse than for basic telephone service handled in these conditions.

Otherwise, if the network is operating under abnormal conditions and a trade-off exists between speech quality and connectivity, connectivity should have priority over speech quality.

4. General Provisions

General provisions related to access to emergency call handling are included in directive 2002/22/EC [1] and documents associated with this directive [2] and [3]. Some of them are described in the following sections of this article.

4.1. Ability of Network Resources to Fulfill User'S Needs

According to the directive mentioned above, in addition to any other national emergency call numbers specified by the national authorities, all end users of publicly available telephone services should have the possibility to call the emergency services free of charge by using the single European emergency call number 112. They should be able to do so without any modifications to terminals, networks and devices on the emergency services provider side.

It should be possible to make emergency calls from public and private payphones at any time without the assistance of an operator, on the same principles like from normal phones. Location information within a private network should be available when possible and comply with the requirements of relevant emergency authorities in the area.

Directive 2002/22/EC [1] requires also that emergency calls should be possible even if a voice communication terminal equipment has a PIN-coded lock of the keypad.

The probability that user will be able to make a basic telephone call to appropriate emergency service should be maximized as well.

4.2. Ability of the Public Network Access Point to Enable Emergency Calls

The public network access point should enable emergency calls in each situation, even when normal originating calls have been barred (e.g., because of non-payment of bills) or mobile phone is protected by an identification/authentication procedure. It should enable emergency call originating in a visited network if the mobile phone is technically compatible with the alternate network.

4.3. Recognition and Treatment of Emergency Calls by the Originating Network

Originating network should recognize emergency calls by means of the emergency call number 112 in addition to the local national emergency numbers valid in the originating network.

For each emergency call the originating network should generate emergency call-related information (e.g., location of the caller and calling line identification) and deliver this information to the PSAP or to the corresponding emergency control centre. This information may either arrive at the destination point at the same time as emergency call or be available for retrieval on demand from this point during the call. Handling of emergency call-related information should not delay answering of emergency call.

4.4. Delivering Call-Related Information Concerning User Location

Caller location information may be a geographical address or a set of geographical coordinates. This information enables the emergency control centre to determine the caller's location at the time of calling. The information should be accessible for as long as the emergency lasts via standardized interface after the initial contact is made.

According to the directive 2003/58/EC on privacy and electronic communications [4], public telephone network operator should forward to PSAP the best information available as to the location of the caller, to the extent technically feasible. For each emergency call for which the subscriber number has been identified, public telephone network operator should enable the PSAP to renew the location information through a call back functionality for the purpose of handling the emergency.

In the first case the location information is transferred to the destination point in the push mode because the information is automatically pushed with the initial call together with information contained in the calling line identity (CLI). In the second one, the information is transmitted in the pull mode on demand, using the CLI and preferably the emergency location protocol (ELP) [5].

Generally, location information is based on the calling line number. In a wireline network this information is received together with emergency call. When emergency call is made from mobile phone operated without a SIM card (subscriber identity module card), originating network cannot transmit CLI information to the PSAP.

4.5. Delivering Call-Related Information Concerning User Identification

For every emergency call made to the number 112 originating network should transmit to the PSAP the calling line number of the access (CLI). The emergency control centre should be equipped in functionality available to return a call to the number in the CLI.

If emergency calls are made from mobile phone operated without a SIM card, originating network cannot transmit CLI information to the PSAP because the CLI cannot be determined. In the countries where this is authorized, as an alternative solution, the equipment identity number like international mobile equipment identity (IMEI) may be transmitted by the originating network.

4.6. Handling of Emergency Calls Between Networks

Originating networks should transmit their network identification to the emergency control centre according to the directive [4] which requires that all location information provided to the PSAP is accompanied by an identification of the network from which the call has originated.

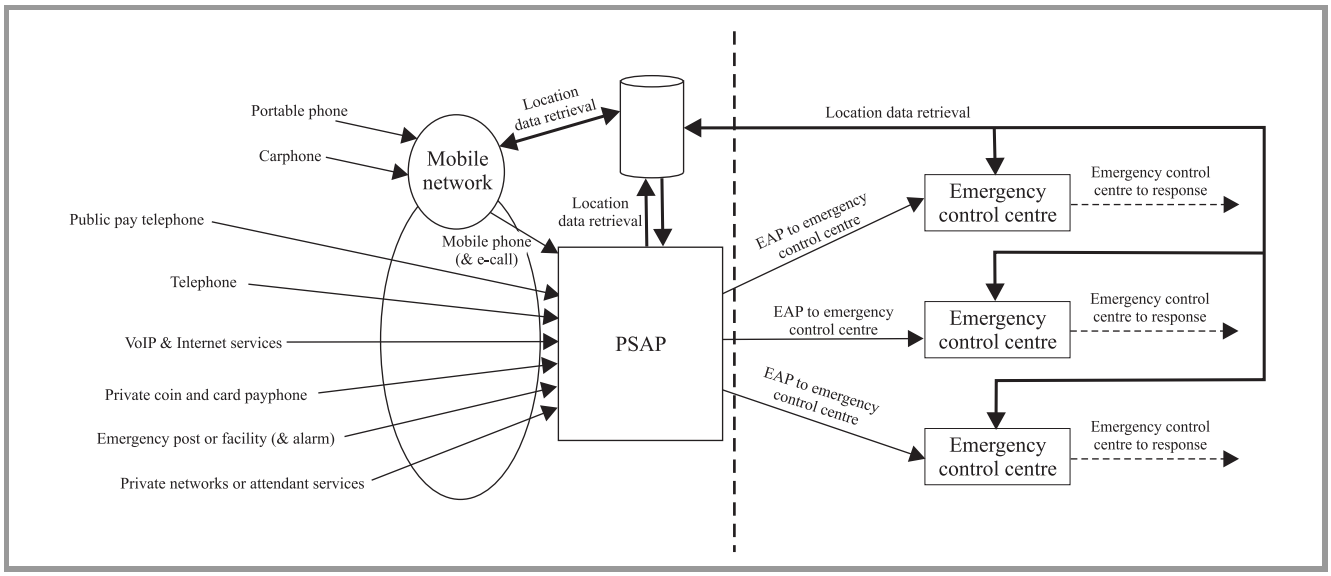

Fig. 1. Basic functional architecture [2].

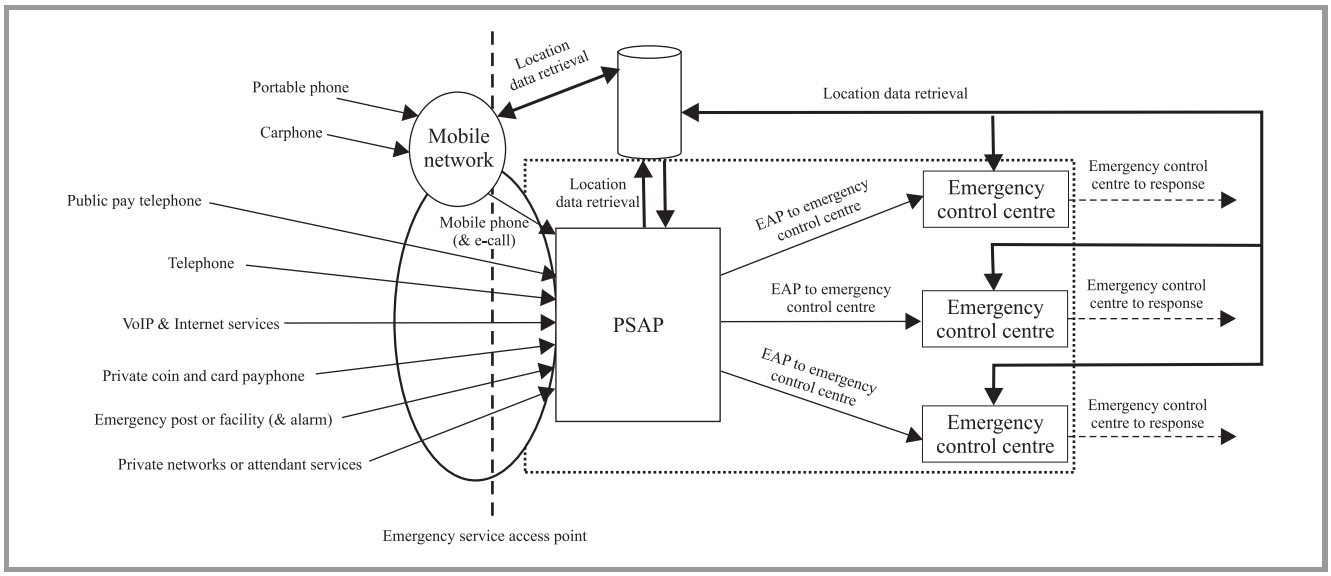

Fig. 2. Integrated PSAP and emergency control center [2].

If the originating network is not connected directly to the PSAP, a transit network is used for transfer of emergency call-related information to the destination point as well as specific routing number (destination number) for identifying responsible emergency service for a specific area.
The transit network should forward this information to the PSAP immediately and in transparent mode, without modification.

4.7. Providing Termination of Emergency Calls to the PSAP

The network should deliver the emergency calls together with any related data, without delay and modification to the PSAP which is directly connected this network. If delivering an emergency calls to the appropriate PSAP is not possible, it must be forwarded to the alternative PSAP.

The PSAP should be provided with access to all of the CLI information. PSAP should be able to release or block repeated nuisance call attempts to the emergency numbers. Only PSAP should be responsible for release of emergency call.

5. The PSAP's Architecture and Organization of the Emergency Control Centres

Basic functional PSAP architecture is illustrated in Fig. 1. Depending on PSAP and emergency control centre physical locations this logical architecture can be mapped into two physical solutions shown in Figs. 2 and 3.

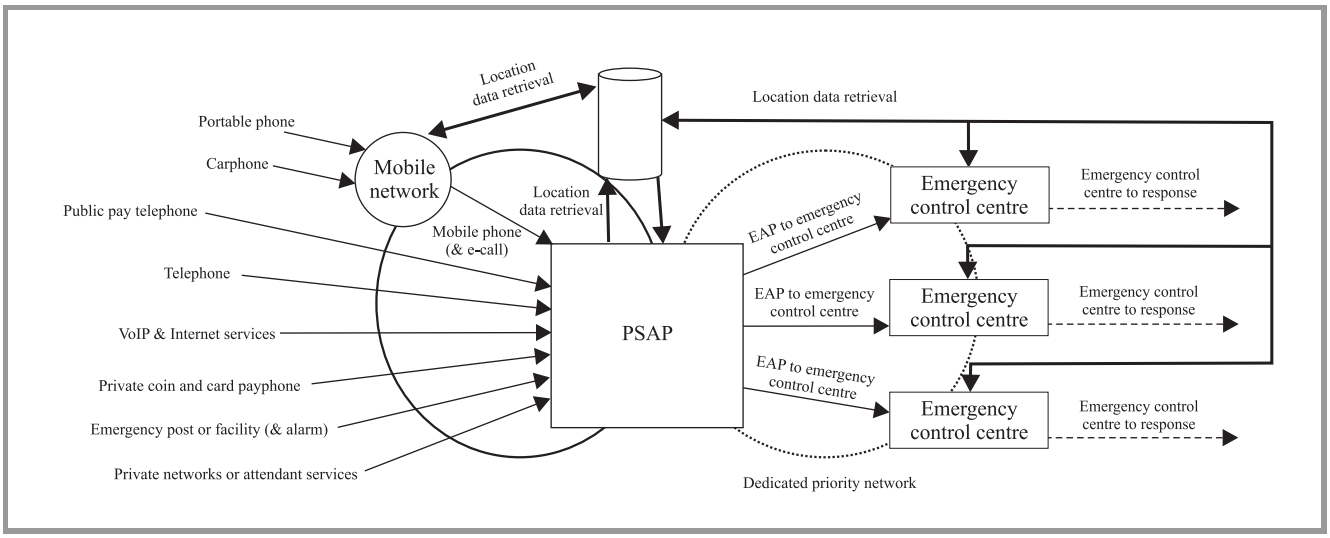

Fig. 3. PSAP on edge of the public network [2].

In the first case, illustrated in Fig. 2, the PSAP and emergency control centre functionalities are integrated into the same physical entity.

In the second solution, shown in Fig. 3, the PSAP sits at the edge of the public network and its functionality is distributed and separated from functionality of the emergency control centre. In this case the network between PSAP and emergency control centre is a dedicated priority network, built using leased lines or secure virtual private network (VPN).

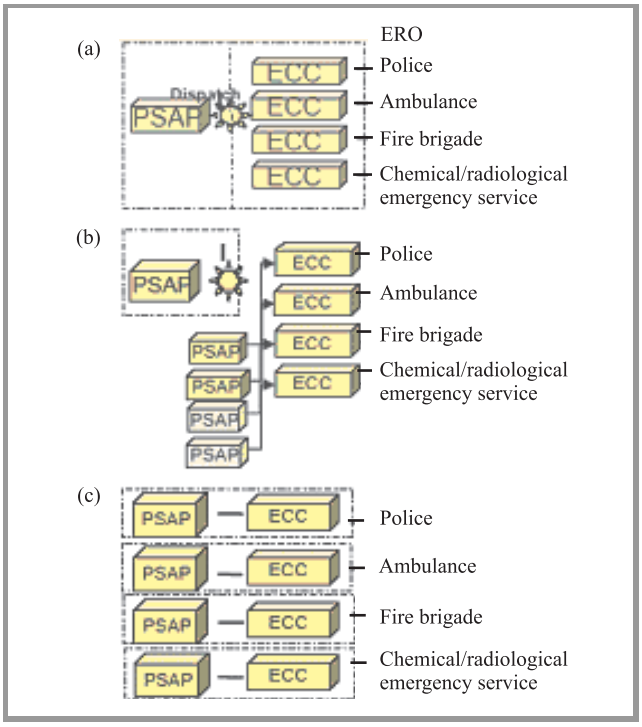

Fig. 4. Basic types of organizational setup [3]: (a) single level 1 PSAP dealing with all emergencies; (b) single level 1 PSAP dealing with all emergencies + directly reachable ERO's having their own answering points; (c) separate PSAPs dealing with emergencies.

Three types of organizational setup of PSAP, ECC and emergency response operations (ERO) recommended by Expert Group on Emergency Access (AGEA), which is the subgroup under the Communication Committee (COCOM) as well as the Technical Group chaired by European Commission (EC), are presented by Fig. 4.

6. Evolution of Regulations Concerning Emergency Calls

6.1. Previous Requirements

Obligations related to emergency calls were defined for the first time in the council decision 91/396/EEC [6]. This document required, in addition to other national emergency numbers, the Member States to ensure that the number 112 was introduced in the public telephone networks, as the number preferred by EC, by 31 December 1992, with a possibility for derogation until 31 December 1996 under certain conditions, e.g., due to high implementation costs. Moreover, the Member States should ensure that emergency calls are correctly received and routed to the appropriate emergency control centre according to technical capabilities existing in the public networks.

Next obligations were defined in the directive 97/13/EC [7], requiring to enable emergency calls even when the normal originating telecommunications services have been barred, e.g., due to of non-payment of bills.

Then, the obligations were included in directive 98/10/EC [8] which more precisely determined the requirements for the emergency calls handling given in using the single European emergency call number the council decision 91/396/EEC [6]. The directive required that it was possible to make emergency calls from public telephones 112 and other national emergency numbers, free of charge and without having to use any means of payment.

6.2. Main Regulations Included in the EU Directives

In the next edition of Community regulations called the "packet of directives of 2002", the requirements for emergency calls made to number 112 was defined in 26 article of universal service directive (2002/22/EC) [1]. In this document European Commission retained all important obligations included in the mentioned above directives and council decision.

First of all, the universal service directive requires it is possible to make emergency calls from public telephones using the single European emergency call number 112 and other national emergency numbers, free of charge and without having to use any means of payment. It is also required that emergency calls can be routed to, and handled within, the appropriate emergency control centre. The users shall be able to make a basic telephone call to an emergency service from any terminal that supports outgoing calls to publicly available telephone services. In particular, this requirement regards the case where emergency calls are made from mobile phones operated without a SIM card.

Moreover, this directive contains new obligations added by the EC. In particular, it is required that public network operators make caller location information available to authorities handling emergencies, to the extent technically feasible, for all calls made to the single European emergency number 112. The directive requires Member States to inform the users about E112 services. The Member States should provide adequate information to their citizens about the existence, use and benefits of E112 services. Citizens should be informed that 112 can connect them to emergency services all across the European Union and that their location will be forwarded. They should also be informed about the identity of the emergency services that will receive their location information and of other necessary details to guarantee fair processing of their personal data.

The universal service directive requires Member States to ensure that the obligations on the processing of caller personal data are respected. However, the directive 2002/58/EC [4; art. 10] permits the network operators to override the restrictions on calling line identification for emergency calls. So, this regulation (possibly only for emergency call purposes) eliminates the protections which users can use in case of other services.

The above mentioned elements form the set of regulations and conditions for their implementation in the Member States, which will be implemented on the principles that are appropriate for such low acts like directives.

6.3. Actions of European Commission Related to Providing Access to Location Information

The next step in creation of regulations regarding user location was Commission recommendation [9]. This recommendation was based on art. 19 of the framework directive 2002/21/EC, so this document has a high law status. Regulations included in this recommendation should be implemented unless serious obstacles exist.

This recommendation determines a number of important elements concerning the scope and mode of caller location (push/pull). This document confirms that location-enhanced emergency call services comprise emergency calls made to number 112 and other national emergency numbers. It means that the Member States with multiple national emergency numbers will have implementation cost higher than others using only one European emergency call number 112.

This document recommends that the "best effort" principle is applied for delivery of location information to PSAPs and that this information is transmitted in a "push" mode. Moreover, the document requires that location information is provided in a non-discriminatory way. In particular, public telephone network operators should not discriminate between the quality of information provided about their own subscribers and other users.

6.4. Proposals of Changes to EU Regulations

European Commission currently considers changing certain regulations concerning emergency call handling.

One of them regards the obligation for public telephone network operators to make caller location information available to authorities handling emergencies to the extent technically feasible. European Commission wants to delete condition "to extent technically feasible".

The second one regards delivery of location information only in the push mode. Moreover, EC recommends that the network operators were debited a cost of data transfer in this mode.

The proposals mentioned above are related to eCall project having a high priority among EC initiatives. The possibility to provide accurate location information for each call in push mode is fundamental to implementation of this project.

6.5. Regulations Included in Polish Law

6.5.1. Obligations Concerning Emergency Call Handling

Obligation for public telephone network operators to make caller information available to authorities handling emergencies is the key regulation concerning emergency calls handling. Set of obligations directly concerning emergency calls is included in the telecommunication law [10] and in other acts having obligatory status. The current status of Polish law concerning E112 determines the elements described below.

6.5.2. Obligations Regarding National Emergency Number

Fundamental obligation included in [10; art. 77] requires providers of publicly available telecommunication services to ensure that emergency calls made from any terminal to emergency numbers are free of charge. Emergency number

is defined in article 2, point 21 as a number available to responsible nominated emergency services specified in the national numbering plan [11]. The emergency numbers are associated with emergency services, including police, fire service, emergency medical services, emergency water services, emergency mountain rescue services and emergency gas services.

6.5.3. Obligations Regarding Assignment of Emergency Calls to the Appropriate Emergency Control Centre

Proper regulation is given in [10; art. 77, par. 2]. According to this obligation, emergency call should be routed to, and handled within, the appropriate emergency control centre. Nominated emergency control centres of the emergency organizations deal with emergency calls from defined geographical areas. Emergency calls are routed to appropriate destination point according to mapping between the location of the caller and the emergency control centre.

6.5.4. Data Available to Responsible Emergency Services

According to [10; art. 78, par. 1], public telephone network operators should make caller location information available to nominated emergency services to the extent technically feasible. The key meaning for this purpose have data regarding caller identification. Appropriate regulation is given in [10; art. 78, par. 1], which requires that public telephone network operators should make calling line identification available to responsible emergency service for this area. According to article 78, par. 1, section 1 [10], user identification should be possible also when the calling line identification is restricted. In the light of the article 78, par. 8 [10], location data should be provided without caller permission if necessary for handling of emergency calls.

6.5.5. Requirements Concerning the Real Time Transferring Data

The article 78, par. 1 [10] requires providers of publicly available telecommunication services to make caller location information available to nominated emergency services in real time. Delivering location information in real time means that delay between receiving of data request message and setting of requested data should not be significant.

National regulations do not precisely define this parameter because it is difficult due to different technologies used in Polish network. Location data based on cell ID methods can be made available faster than when GPS technology is used.

In the CGALIES report [12] it is assumed that coarse location information should be available in 7 s and accurate information should be available in 30 s.

6.5.6. The Changes Required in Polish Regulations

It is necessary to make some changes in [10; art. 77] which obliges providers of publicly available telecommunication services to ensure that emergency calls are free of charge.

First of all this obligation should be limited to providers of publicly available telephone services, not telecommunication services providers. Moreover, obligation related to providing location information should extend to all telephone services providers, because this obligation should be directly associated with providing telephone services.

The number of emergency numbers for which network operators are obliged to provide full functionality should be limited in accordance with concept of PSAPs organization.

In the light of the recommendation [9], the Member States should define precise obligations for telephone service providers related to providing caller location information, as existing general requirements will not suffice in the future.

7. Conclusion

Caller location information is critical for efficiency of emergency services, requiring that mobile positioning function is available anywhere in the network coverage area, anytime. Unfortunately, no method available today meets all requirements of emergency services.

Cell identity (cell ID) and its variants cannot meet accuracy requirements, although only these technologies are able to operate over 100% of the area covered by a network. They can be used only in dense urban environment.

Estimated observed time difference (E-OTD) can meet requirements in all environments except in the rural areas where the network may not provide sufficient number of cells to enable triangulation. This technology works where three or more base transceiver stations (BTS) are visible and the results obtained by E-OTD degrade to cell-ID when only one BTS is visible.

Assisted global positioning system (A-GPS) can fulfill the accuracy requirement in all environments, but performance of this technology in certain indoor environments may be problematic, although there are techniques available to increase the sensitivity of A-GPS receivers and hence improve the probability of a location fix as well as the resulting accuracy indoors.

So, from a purely technical point of view the best solution would be a combination of different technologies; introduction of hybrid technologies would improve the chance of meeting accuracy requirements.

In summary, regarding the works conducted in the technical as well as regulatory areas related to emergency calls handling, one sees recent progress in several fields. However, some problems related to emergency calls aren't solved yet. The most important problem now regards interoperability. It should be ensured that different manufacture's equipments are able to interoperate with each other correctly and without modifications. It should be noted that new standards must be defined to ensure progress in the development of E112.

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Wojciech Michalski was born in Bogate, in Poland, in 1952. He received the M.Sc. degree in telecommunications engineering from the Technical University in Warsaw in 1977. He has been with the Switching Systems Department of National Institute of Telecommunications (NIT) since 1977, currently as a senior specialist. His research interests and work are related to PSTN backbone and access networks, GSM networks and IP networks. He is an author and co-author of technical requirements and many documents concerning telecommunication networks, services and protocols.

e-mail: W.Michalski@itl.waw.pl
National Institute of Telecommunications
Szachowa st 1
04-894 Warsaw, Poland